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scarcely permit it. Those who may be interested in the subject are at liberty to make such inquiries of the writer as they see fit. Suffice it to say that in a country like our own, well traversed by water ways, a marine laboratory capable of rapid locomotion, at an exceedingly small cost, seems a very desirable adjunct to true university work in natural history subjects.

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SCIENTIFIC LITERATURE.

Ueber Verwachsungsversuche mit Amphibienlarven.

Von DR. G. BORN. Leipzig, W. Engelmann. 1897. (Reprinted from *Archiv für Entwicklungsmechanik*, Band IV.) 8vo. Pp. 224. Pls. I.-XI.

Professor Gustow Born is distinguished among living morphologists for the novelty and thoroughness of his investigations. It is to him that we owe the section modelling which is now so much used for the anatomical reconstruction of embryos, and which he has himself applied with brilliant results to the study of the development of the thyroid and of the heart. To him we owe also the experimental demonstration of the isotropism of the egg. In the present work we encounter again striking originality of method, coupled with extraordinary patience and thoroughness in the execution of the research. The method consists in the artificial union of two amphibian larvæ; this is accomplished by making a smooth cut on each larva, adpressing the two cut surfaces and allowing them to grow together; the natural fusion begins in half an hour to express itself and is complete in a few hours; in successful cases the united pair develop in unison and remain alive for weeks. Dr. Born's patience shows itself in the number and variety of fusions accomplished and in the exhaustive anatomical study of the developed monstrosities.

The only earlier experiments on fusion of two individuals were those of Trembley on Hydra, recently repeated by G. Wetzel. On the other hand, the announcement of Born's results has already occasioned a number of similar experiments on other animals. W. Roux appears to have first discovered the extraordinary power of the eggs and young larvæ of frogs of with-

standing severe mechanical injury, and others have demonstrated the wonderful regenerative faculty of Amphibia during the early stages. Born has taken advantage of these characteristics to secure the concrescence of two individuals which develop afterwards as one. The spread of the ectoderms is the first step of the union, and there is in a short time a complete sheet of this tissue, with no visible break or trace of demarcation, extending from one larvæ to the other and covering the wound. This healing over is effected by the expansion of the sheet of ectoderms, and this expansion is not due to multiplication of the cells. Most of Born's experiments were made on larvæ of four millimeters (more or less) in length and on the following species: *Rana esculenta* *Bombinator igneus* and *Pelobates fuscus*; the larvæ of toads and of *Rana fusca* proved less favorable. Pieces of almost any size can be made to unite either of the same, or of different larvæ, and even of larvæ of two species. When the experiment succeeds such united pieces will live for about three weeks, or, in other words, until the supply of yolk material for the maintenance of growth is exhausted, but, if one or both the pieces have a digestive tract with mouth and arms, the united pieces may continue to develop indefinitely, and in such cases the blood channels of both species acquire open communication with one another, so that even when there is but one heart the blood circulates through both components. During the life of the fused larvæ, their development, their differentiation proceeds, each organ continues its progress. The development essentially follows the principles of Roux's mosaic theory.

The following schedule indicates the variety of successful unions accomplished by Professor Born:

- A. Experiments on single larvæ.
 1. Pieces cut off and allowed to continue their development.
 2. Larva cut through and the pieces reunited.
- B. Fusion of two larvæ, or parts of two larvæ.
 1. Both larvæ of the same species.
 - a. Fusion of anterior with posterior pieces.
 - b. Fusion by the ventral surfaces.
 - c. Fusion of the posterior piece of one larva with the ventral side of another.

- d. Fusion of the anterior piece of one larva with the ventral side of another.
- e. Fusion of two posterior pieces.
- f. Fusion of the heads of two larvæ.
- g. Fusion of anterior pieces.
- 2. The larvæ belong to different species or even genera.
 - a. Fusion of the ventral surfaces.
 - b. Fusion of the posterior piece of one larva with the ventral surface of the other.
 - c. Fusion of an anterior with a posterior piece.
 - d. Fusion of the heads of two larvæ.

Every one of these unions was repeated many times, and the monograph presents an exact description of the anatomical condition of several specimens of each form of double larva, after the development had continued some weeks. These descriptions are based upon the examination of serial sections, the specimens being sacrificed on the microtomic altar. It is not using too strong a word to characterize the labor involved as enormous. The work, moreover, bears throughout the stamp of extreme conscientiousness.

It is impossible to enter here into details, but some of the general conclusions formulated by the author are so interesting that they are here presented. If, by the fusion, corresponding organs or their anlagen are brought into contact they unite continuously by the conecrescence of the specific tissue of the organ (the process might be appropriately named '*Histofusion*,' *Rev.*). If the anlagen of unlike organs are brought in contact they become united by connective tissue. If the similar organs are hollow not only do their walls fuse, but also smooth open communication of their cavities is established, and in such cases it is not necessary that parts precisely corresponding should be joined. The different parts of the digestive tube will fuse, or the spinal cord will unite with the brain, and there will be produced a smooth passage from the cavity of one to that of the other, similarly in cases of fusion of the abdominal, pericardial or vascular cavities, of hearts, wolffian ducts, etc. Tissues are found united in this way which at the time of the union were still undifferentiated. Under certain conditions

ectodermal and entodermal epithelia may become connected. The notochord takes an exceptional position in that the notochord of one piece does not conecresce with that of another. The growing together of similar organs or tissues may occur in any plane or direction; there is no trace of polarity in the growth, such as Vöchting records for plants. The union of two pieces may be not only anatomical, but also physiological, and Born designates this as physiological symbiosis. It occurs in various degrees. In probably all cases the blood vessels are in open communication, so that the circulation is common to both components. A higher degree of symbiosis is marked in the cases where the intestine of the major larva has annexed a piece of the intestine of the minor, and both function together to the common advantage, or when the two larvæ have a stretch of intestine in common. The highest degree is reached when a whole end of the body, together with all its organs, is replaced, lengthened or doubled, for then the posterior piece from one larva works with the anterior piece of another, as if they were one individual. The highest degree is equally attained when the right and left halves of two larvæ are united in a single individual. The '*individuum*' is not dependent on the derivation from one egg. We have a single organism from two eggs (einen einheitlichen Organismus aus zwei Eiern). In the derivation from a single ovum there is no mystic, metaphysical unity.

The development, from the stage at which the experiments begin, depends upon self-differentiation of the single parts. No correlative influence of the surrounding parts can be recognized; the development is mosaic—Feis' organic areas (*organbildende Keimbezirke*) are partitioned off.

We commend this work to the attention of all biologists, and venture to predict that further important deductions will be garnered from these experiments of Professor Born, supplemented as they soon will be by additional researches.

CHARLES S. MINOT.

The Concise Knowledge Library: Natural History.

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